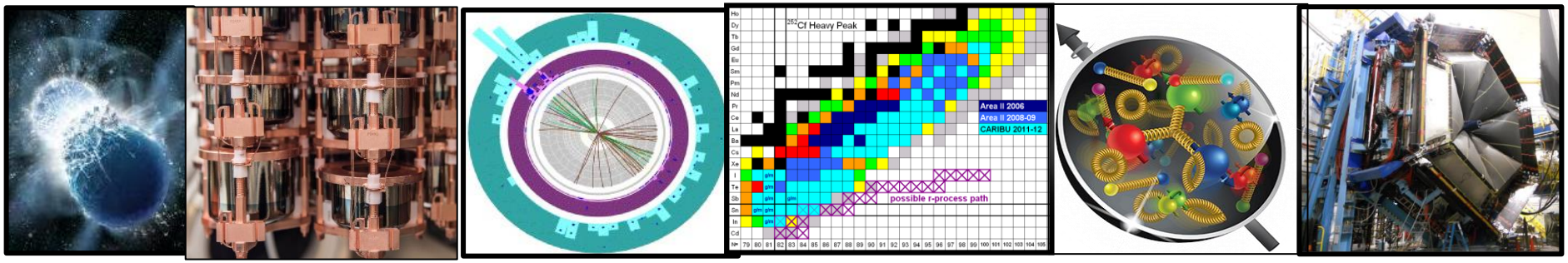
U.S. DEPARTMENT OF ENERGY | Office of Science

DOE Nuclear Physics Research, Facilities, Priorities, and Opportunities

RHIC/AGS User Meeting

June 9, 2022

Dr. Timothy J. Hallman
Associate Director of the Office of Science
for Nuclear Physics



DOE NP is a Primary Federal Steward of U.S. Nuclear Physics Research

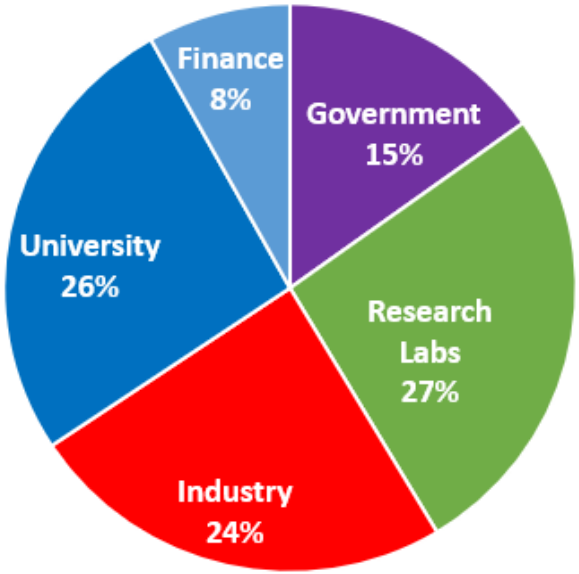
DOE NP supports ~ 90% of the nation's investment in basic research in nuclear physics in the U.S.

It is responsible for Strategic Planning, Funding, and Implementation

Goals and Deliverables:

- Knowledge
- Leadership class facilities
- New technology
- A highly-trained, diverse workforce capable of supporting DOE & other missions

Where NP PHDs go



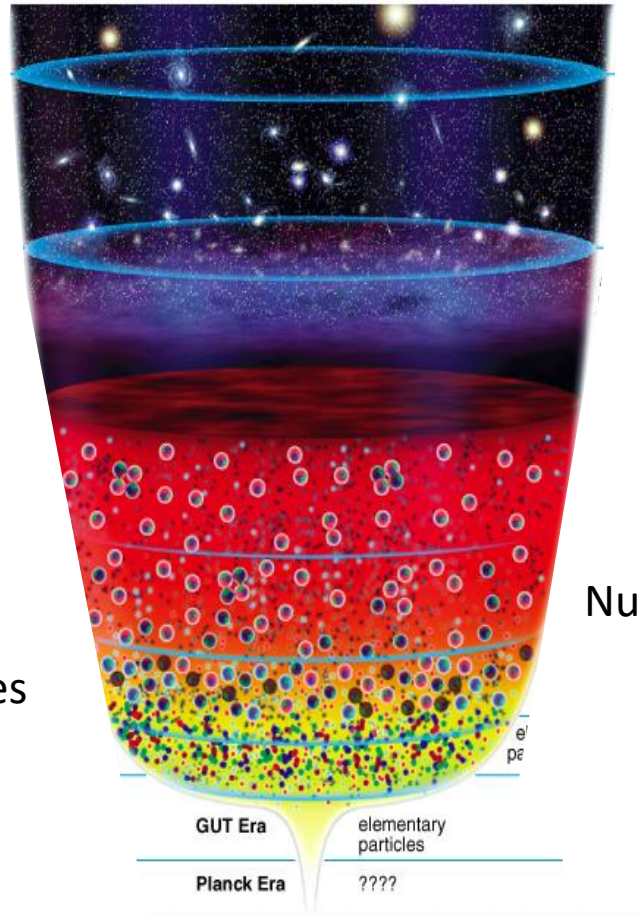
U.S. science, commerce, medicine, defense —all benefit, in part, from a stable level of sustained competence, capability, capacity, and leadership in nuclear physics; DOE NP is the U.S. steward responsible for reliably delivering that benefit.

The Reach of DOE NP Science Research

Present Day

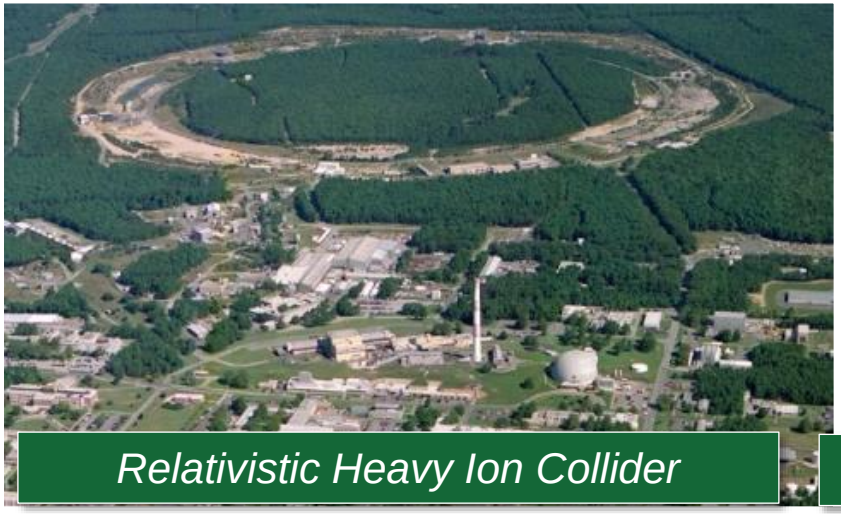
NP Discovery Horizon

Evolution of the Universe

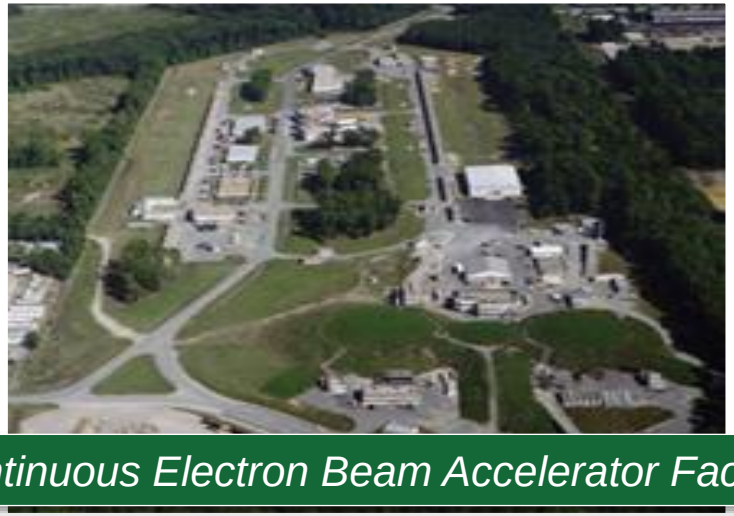


The vast range of time (μsec to 13.8B years) and physical scales (quarks to galaxies) requires "microscopes" and tools of varying resolving "power"

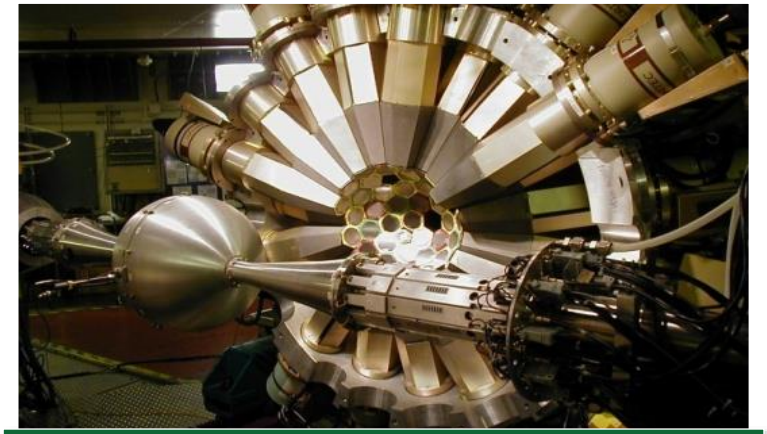
A Major Part of NP Stewardship is Operating:



Relativistic Heavy Ion Collider



Continuous Electron Beam Accelerator Facility



Argonne Tandem Linac System

Facility for Rare Isotope Beams

"Microscopes" of Varying Resolving Power

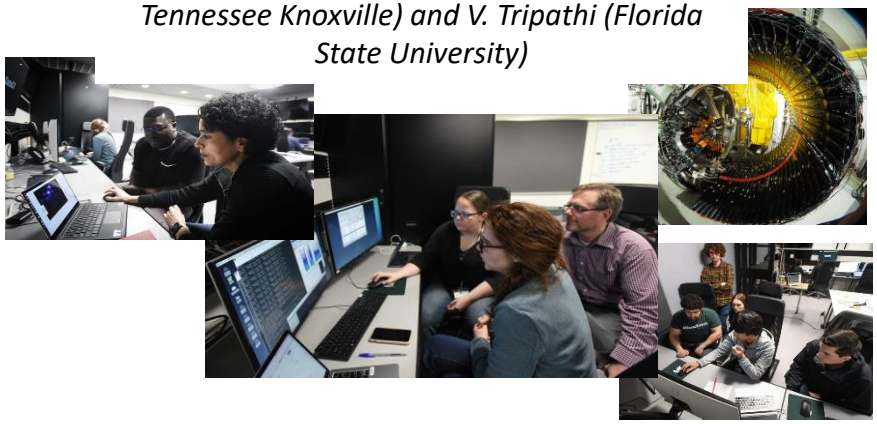
FY 2022 Highlight

Secretary Granholm at the FRIB Ribbon Cutting

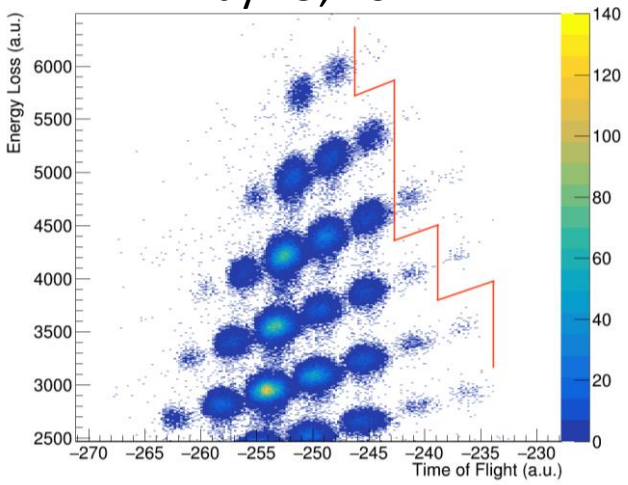
May 2, 2022

FRIB Experiment E21062

Spokespersons: *J. Allmond (ORNL), H. Crawford (LBNL), B. Crider (Mississippi State University), R. Grzywacz (University of Tennessee Knoxville) and V. Tripathi (Florida State University)*



May 19, 2022



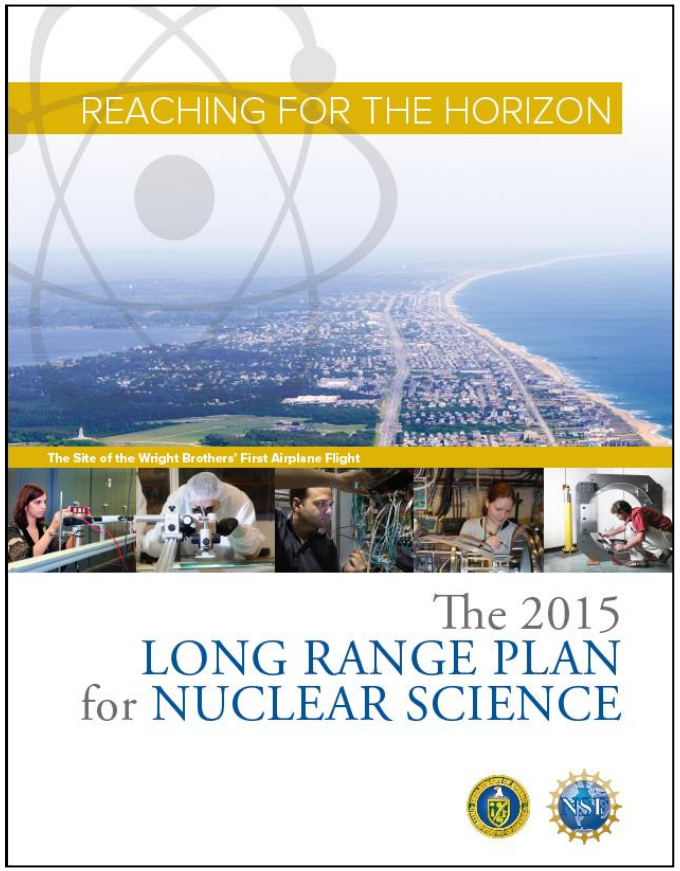
The High-Level DOE NP Work Plan

1. Operate and get science out from the Relativistic Heavy Ion Collider (RHIC),the Continuous Electron Beam Accelerator Facility (CEBAF), the Argonne Tandem Linac Accelerator System (ATLAS) and the Facility for Rare Isotope Beams (FRIB)

2. Make progress on a U.S.-led ton-scale neutrino-less double beta decay experiment.

3. Start construction of a high-energy high-luminosity polarized electron-ion collider (EIC)

4. Implement smaller scale instrumentation to take advantage of facility capabilities

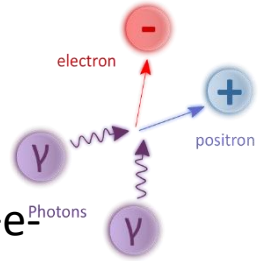


The work plan centers on scientific discovery: to understand all forms of nuclear matter. The knowledge gained benefits energy, commerce, medicine, and national security.

Beginning preparations are getting underway for the next Long Range Plan Exercise

Recent Impactful Accomplishments

- Discovery that ionizing radiation reduces coherence time for entangled quantum states
  - Need new quantum materials or/and underground Quantum Computing



- First known observation of the Breit-Wheeler two-photon process at RHIC
  - Confirmation of Quantum Electro-Dynamic (QED) process; possibility of e^+e^- pair production via lasers

- Discovery that heavy nuclei have a neutron skin (CEBAF)
  - New constraints on neutron star radii and their equation of state
- Implementation of dynamical fermions and the real pion mass in Lattice QCD
  - Major advance in fidelity of Lattice Quantum Chromodynamics calculations
- Initiation of the FRIB science program
  - Opening a new frontier to understand heavy element production in cosmos

- Integration of AI technology at CEBAF to make it more fault tolerant
  - Test-bed for use of Artificial Intelligence in accelerator control and optimization

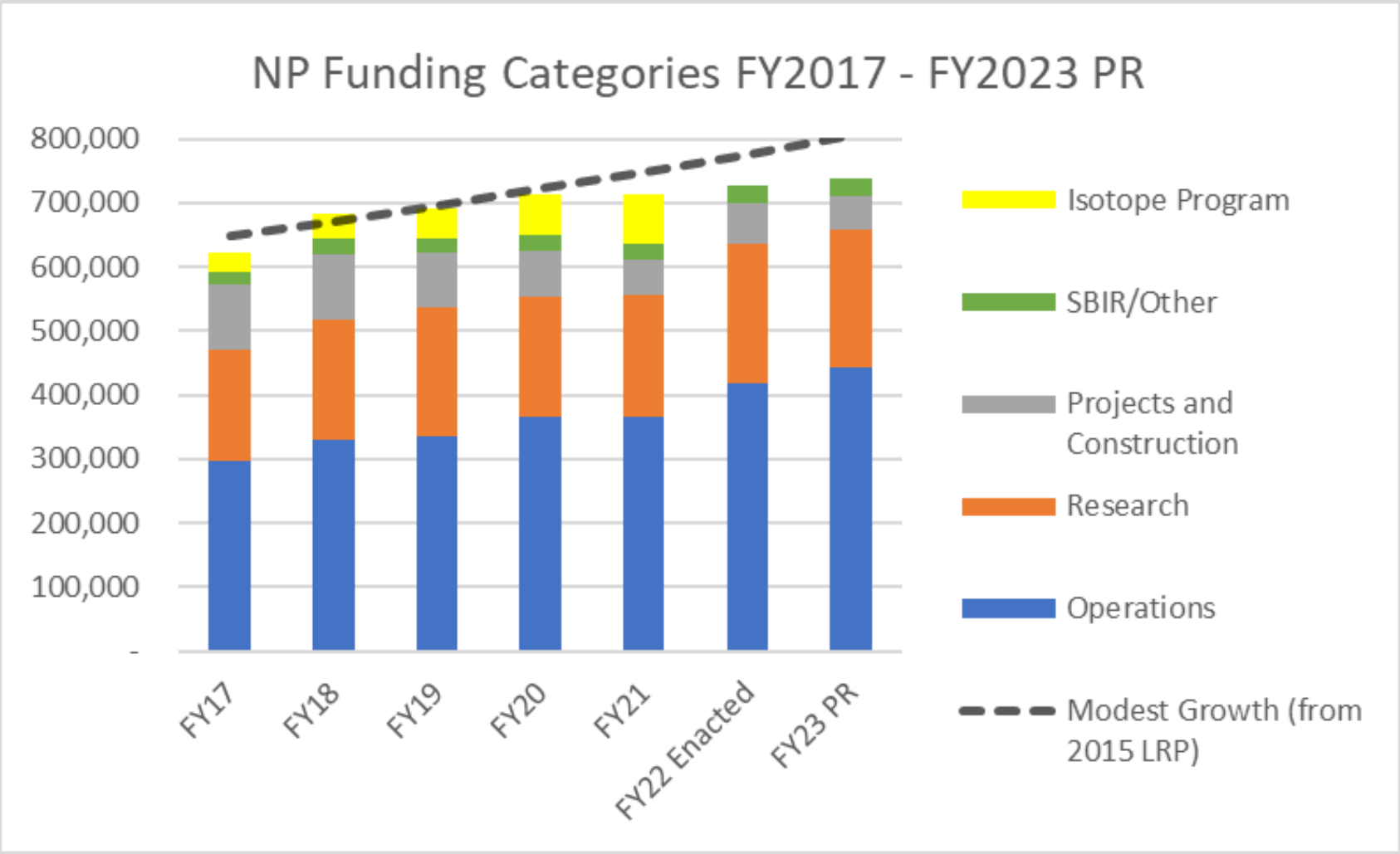
NP Participation in SC Initiatives

SC/DOE Initiatives	FY21 Enacted	FY22 Enacted	FY23 PR
Quantum Information Sciences (QIS)	13,347	10,866	10,866
Artificial Intelligence and Machine Learning (AI)	4,000	4,000	8,000
Microelectronics	-	518	518
Strategic Accelerator Science and Technology Initiative	-	1,037	-
Reaching a New Energy Sciences Workforce (RENEW)	-	3,000	6,000
Funding for Accelerated, Inclusive Research (FAIR)	-	-	2,000
Accelerate Innovations in Emerging Technologies	-	-	4,000

Scientific Discovery Through Advanced Computing	$ 2,878	$ 3,543	$ 3,494

NP is also cultivating the possibility of a symbiosis with NIH to spark a significant advance in imaging useful for both DOE and NIH research

The Trend of Appropriations Supporting the NP Work Plan



Recent Ops increases largely due to bringing FRIB online and making reliability upgrades at CEBAF

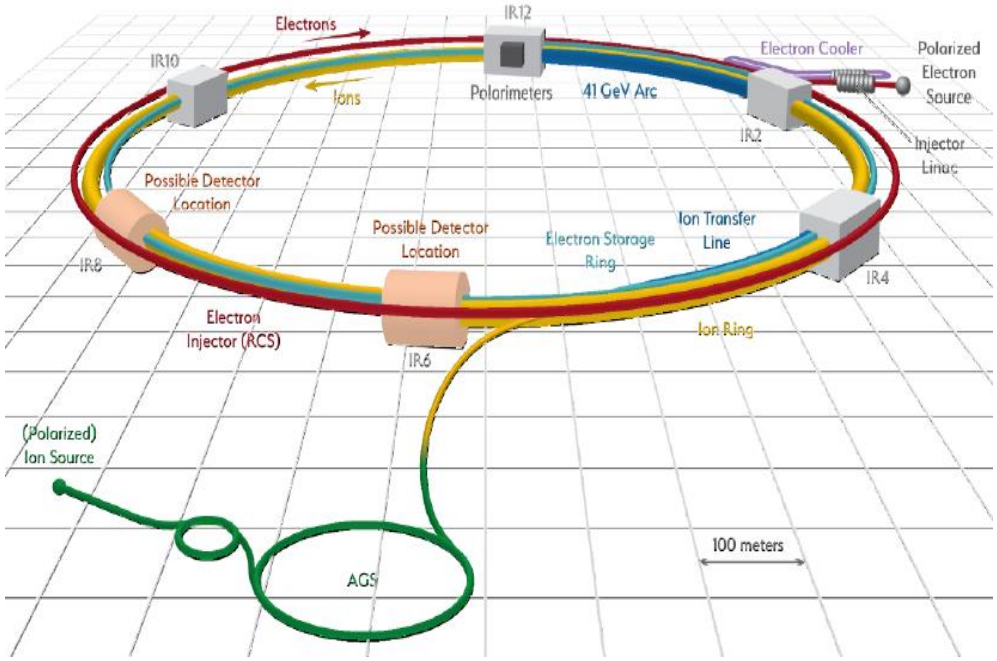
NP Projects: Status and Operations Plan

Project	Location	Status	Cost	CPI	SPI	CD-4	Operation cost plan
Construction Projects							
Facility for Rare Isotope Beams (FRIB)	MSU	CD-4	$730M	1.00	1.00	6/2022	Included in NP budget formulation
Electron-Ion Collider (EIC)	BNL	CD-1	$1.7B to $2.8B			Q4 FY33	RHIC operations funds redirected to EIC project recovered for EIC operations
Major Items of Equipment							
Gamma Ray Energy Tracking Array (GRETA)	LBNL	CD-2/3	$58.3M	0.98	0.94	4/2028	Mostly covered by host laboratory operations experimental support
Super Pioneering High Energy Nuclear Interaction Experiment (sPHENIX)*	BNL	PD-3	$27.0M	1.02	0.85	12/2022	Covered by RHIC operations experimental support
Measurement of Lepton-Lepton Electroweak Reactions (MOLLER)	TJNAF	CD-1	$45.8M to $56.6M			Q4 FY27	Covered by TJNAF operations experimental support
High Rigidity Spectrometer (HRS)	MSU	CD-1	$85.0M to $111.4M			Q2 FY29	Covered by FRIB operations experimental support
Ton Scale Neutrinoless Double Beta Decay (TS-NLDBD)	TBD	CD-0	$215M to $250M			TBD	TBD

Blue indicates “Completed”

In the Future Plan, RHIC Completes its Mission and the EIC is Built

CD-1 was attained in June 2021.



- Located at BNL and with TJNAF as a major partner. Estimated cost between $1.7 and $2.8 billion.
- Utilizes existing RHIC assets; adds electron storage ring, & electron cooling


EIC Dedication

NAS: A US- based EIC will uniquely answer

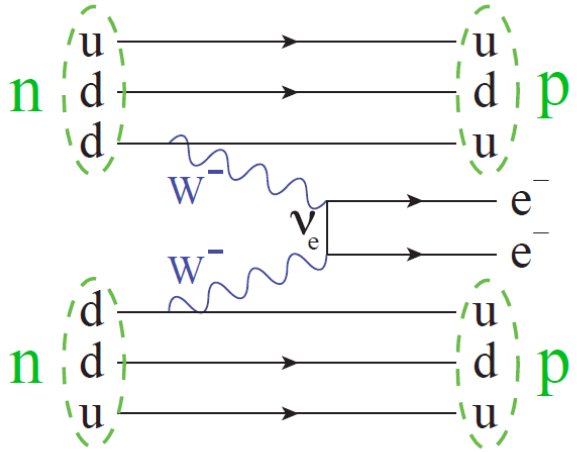
- How does the mass of the nucleon arise?
- How does the spin of the nucleon arise?
- What are the emergent properties of dense systems of gluons?"

The EIC will also maintain U.S. leadership in the accelerator science and technology of colliders

The international community is already highly engaged with 1110 collaborators, from 32 countries, and 235 institutions actively working on EIC development

The Global Campaign to Determine the Fundamental Nature of the Neutrino

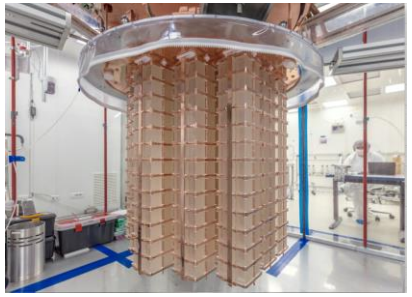
The Search for Neutrino-less Double Beta Decay ($0\nu\beta\beta$): in a selected nucleus, two neutrons decay into two protons and two electrons, with no neutrinos being emitted.

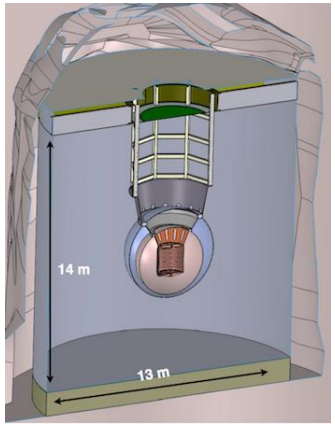


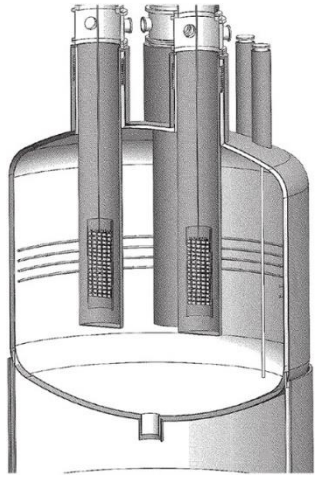
It required the two neutrinos from the two W^- particles to annihilate, proving the neutrino is its own anti-particle

Three Proposed Technologies

- Scintillating bolometry (**CUPID**, ^{100}Mo enriched Li_2Mo_4 crystals)
- Enriched ^{76}Ge crystals (**LEGEND-1000**, drifted charge, point contact detectors)
- Liquid Xenon TPC (**nEXO**, light via SiPM, drifted ionization)





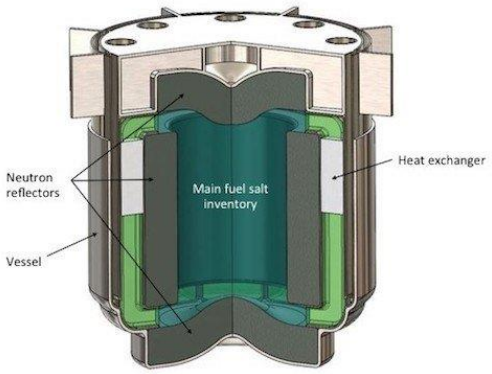


Potential Partners: Italy, Canada, and Germany

The NP Line of Sight to Broader Impacts & Other Missions

NP is providing new and updated nuclear data to existing "customers"

- Working to identify impactful nuclear data needs and leverage resources
  - Ex: Advanced Reactors with DOE/NE, ARPA-E



NP is reaching out to new nuclear data application customers

- Electronics protection (NASA, Missile Defense Agency, Federal Aviation Administration)
- Human safety (NASA [spaceflight], NIH [ion beam therapy])
- Advanced reactors (ARPA-E, NASA)

NP is exploring a mechanism for Rapid Response Nuclear Data

- Many federal agencies have projects with nuclear data shortfalls
- Project funding / scope does not cover nuclear data activities
- USNDP is investigating a process where performers can submit requests for urgent, high impact nuclear data needs

NP Leads a Nuclear Data Interagency Working Group (NDIAWG) that published 4 FOAs

NP Traineeships: 36 Proposals Resulting in 110 Traineeships

NP traineeship award recipients include:

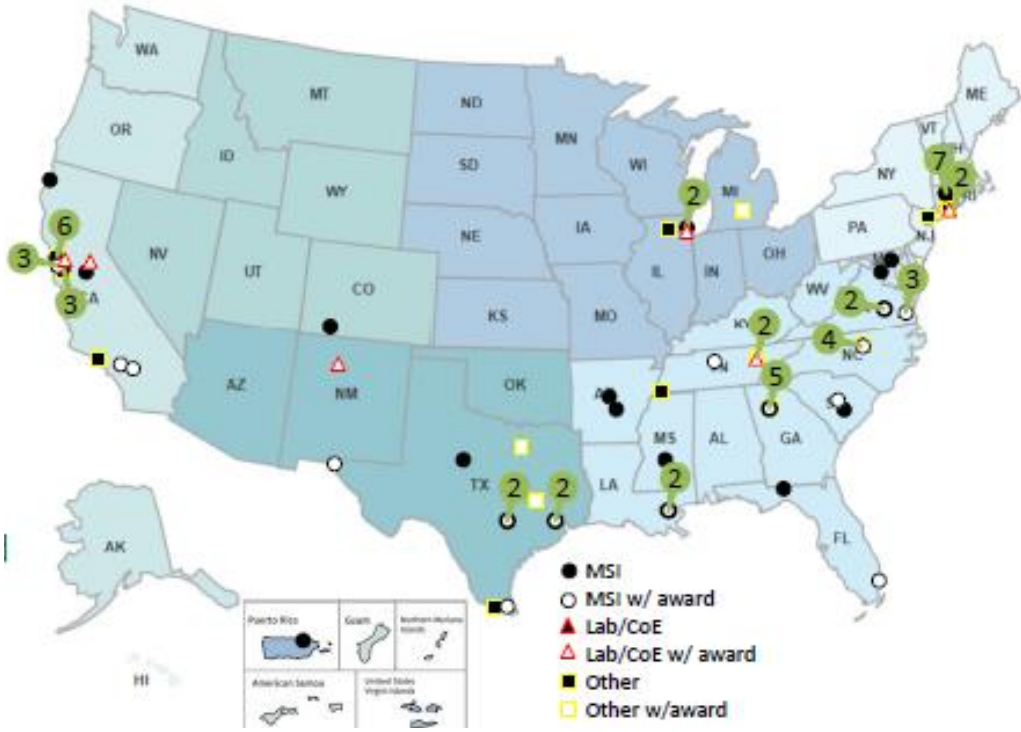
- 18 MSIs,
- 10 other colleges/universities,
- 5 DOE laboratories

MSI award recipient distinctions:

- 9 Hispanic Serving Institutions (HSIs),
- 8 HBCUs,
- 5 Asian American, Native American, and Pacific Islander Serving Institutions (AANAPISI),
- 1 Predominantly Black Institution (PBI)

All other institutions on the map are involved in the traineeship program as recruitment sites (38), Co-Is (9), members of INSIGHT (8), and/or hosts (7)

40% of trainees identify as Hispanic
40% of trainees identify as Black or African American
10% of trainees identify as White
10% of trainees identify as other



Additional NP Traineeship and DEI Information

- The INSIGHT team (left to right): Paul Gueye (MSU), Felecia Commodore (ODU), Geraldine Cochran (Rutgers), responsible to:

  - Assess effectiveness
  - Facilitate communication and coordination
  - Survey to ascertain criteria related to retention
  - Gather data for input to SC

- Very strong statements by NP AD in community forums (APD/DNP Meetings) that the SC Statement of Commitment will be respected in the NP Community and that unwanted or abusive behavior, WILL STOP NOW.

- Planned focus of FY 2023 RENEW investment: vehicle(s) for anchoring sustained investment at HBCUs and MSIs in technical areas important for SC (e.g. imaging, cryogenics) to “uptake” and retain talented trainees

The Main Drivers Accounting for Requested FY 2022 Increases

The FY 2022 Enacted required large increases over FY2021 Enacted
$728M vs $635M (+93M)

• CPP Plan at JLAB	$6M
• Weeks at JLAB	$19M
• EIC	$20M
• Core Research	$12.7M
• FRIB Ops	$27M
• Nuclear Data	$2.8M
• RENEW	$3.0M
• Initiatives	$2.5M
	$93M

NP FY2022 Enacted and FY2023 PR

	FY22 Enacted	FY23 PR
Medium Energy	**$ 196.1 M**	**$ 193.7 M**
CEBAF Ops	$ 142.7 M	$ 143.4 M
Research	$ 53.4 M	$ 50.3 M
Heavy Ion	**$ 255.5 M**	**$ 245.0 M**
RHIC Ops	$ 183.9 M	$ 191.8 M
Research	$ 46.5 M	$ 43.2 M
Project	$ 25.0 M	$ 10.0 M
Low Energy	**$ 199.1 M**	**$ 217.5 M**
FRIB, ATLAS Ops	$ 107.8 M	$ 125.5 M
Research	$ 73.9 M	$ 68.1 M
Projects	$ 17.4 M	$ 23.9 M
Theory	**$ 57.3 M**	**$ 63.0 M**
Research	$ 57.3 M	$ 63.0 M
Facility Construction	**$ 20.0 M**	**$ 20.0 M**
EIC	$ 20.0 M	$ 20.0 M
Total, NP	**$ 728.0 M**	**$ 739.2 M**

Targeted increases are made in the FY 2023 Request compared to FY 2022 Enacted **$739.2M vs $728M (+11.2M)**

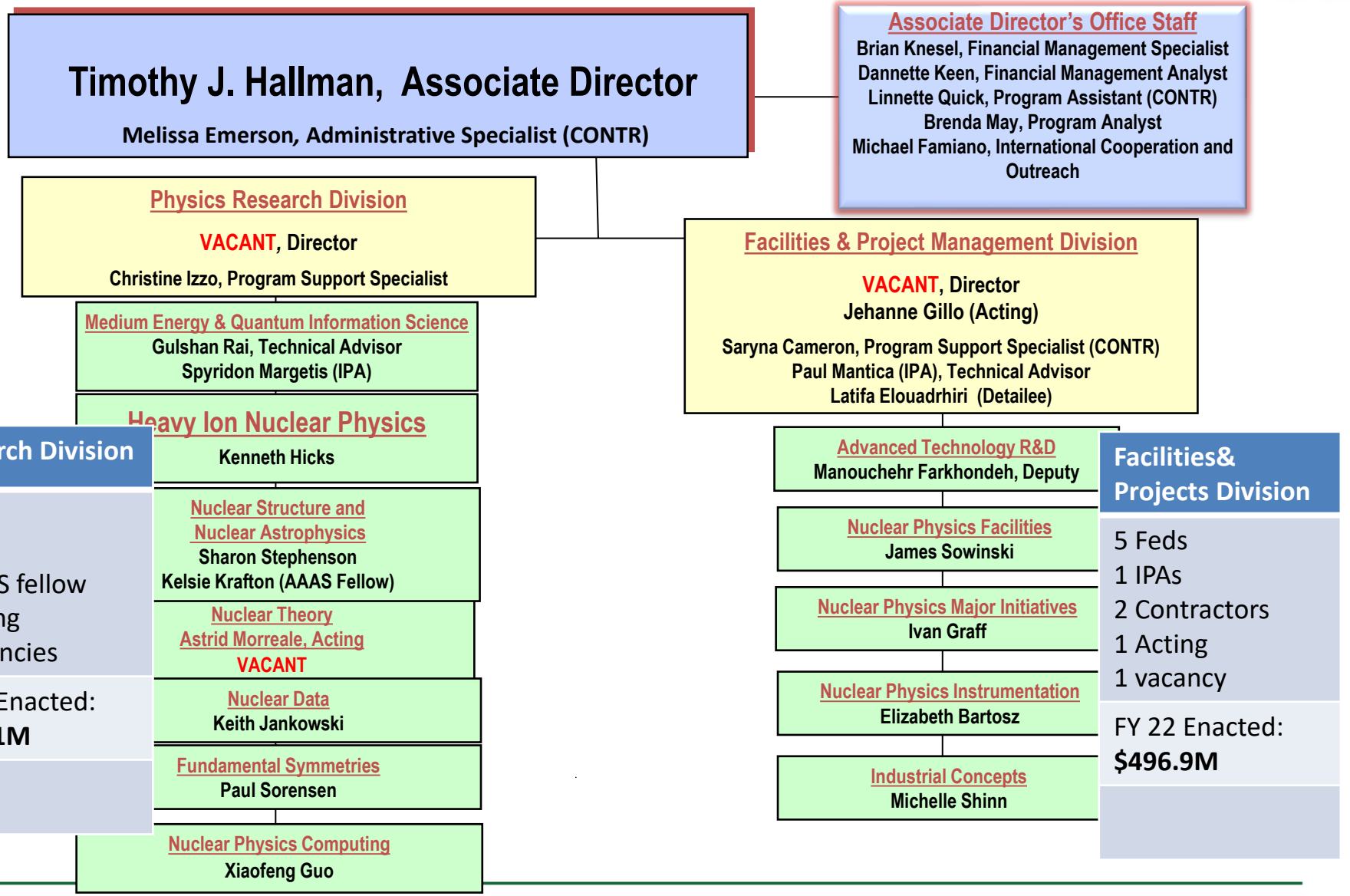
• FRIB Ops	$15.8M
• GRETA	$6.5M
• AI/ML	$4M
• RENEW	$3M
• FAIR Initiative	$2M
• Accelerate Innovation	$4M
	$35.3M

Funds to support targeted increases above the overall NP increase come from the NP base.

FY 2023 Request Highlights - NP

- FRIB begins its first full year of science research studying atomic number 28 nuclei near the limit for nuclear existence
- NP User Facilities (RHIC, CEBAF, ATLAS, and FRIB) all operate at or above 90% utilization
- The Electron-Ion Collider "memorializes" international in-kind contributions as part of finalizing preparations for CD-2 Review, *Approve Performance Baseline.* EIC A/E design is begun.
- sPHENIX begins science research at RHIC to determine the novel properties of the quark-gluon plasma
- LEGEND-200 begins initial search for new physics via the slowest rare decay ever attempted
- Funding for the Gamma Ray Energy Tracking Array (GRETA) MIE is in accordance with technically driven schedule
- NP investment in the AI/ML cross-cutting research and RENEW doubles
- NP participates in the new cross-cutting initiatives in Funding for Accelerated Inclusive Research (FAIR) and Accelerate Innovations in Emerging Technologies (Accelerate)

DOE Office of Nuclear Physics

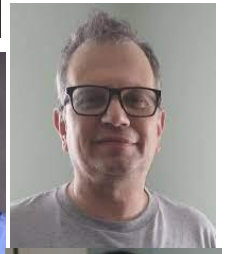


(IPA) – Intergovernmental Personnel Act

Other news

- Charge on Nuclear Data presented at the NSAC Meeting, April 20, 2022 (Virtual)
- Plan for the charge for the next LRP to be delivered at the following NSAC meeting July 13, 2022 (Hybrid Meeting).
- Ken Hicks is officially a Fed responsible for Heavy Ion Physics
- Astrid Morreale is now Acting PM for Nuclear Theory
- Paul Mantica is an IPA in charge of Facilities and Projects Division
- David Cinabro joins NP as a Fed to steward NP Facilities
- Michael Famiano joins NP as a Fed to help steward outreach and international collaboration
- Spiros Margetis is an IPA assisting Gulshan Rai with Medium Energy
- Dannette Keane is a new NP budget analyst with a primary focus on execution
- Melissa Emerson is the new administrative support person for the Associate Director
- Saryna Cameron is the new support person for the Facilities and Projects Division
- Kelsie Krafton is an AAAS Fellow stewarding DEI efforts in NP
- In general NP staff are “back in the office” with modified in-person schedules
- Based on lessons learned from the pandemic Fed travel will likely be reduced, in-person office presence will be reduced, remote work and telework will be more common. DOE supported travel is slowly opening back up but is halted once again to areas experiencing high transmission. Masks are optional.



A Long Tradition of Partnership and Stewardship

There has been a long tradition in Nuclear Science of effective partnership between the community and the agencies in charting compelling scientific visions for the future of nuclear science.

Key factors:

1) Informed scientific knowledge as the basis for recommendations and next steps

2) Mutual respect among scientific sub-disciplines

3) Commitment to the greater good of nuclear science as a discipline

4) Meticulously level playing field leading to respect for process and outcomes

5) Deep appreciation for the wisdom of Ben Franklin

Staying united we can accomplish great things together

Division will setback the entire field and is the last thing needed right now